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RESEARCH ARTICLE

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DEVELOPMENT AND STRENGTH PROPERTIES OF SYNTHETIC FIBER REINFORCED GEOPOLYMER CONCRETE

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ABSTRACT

The present investigation is mainly focused on the effect of fibers on the mechanical properties of geopolymer concrete (GPC) with polypropylene. In this, Class F fly ash (FA) and ground granulated blast furnace slag (GGBS) are used in equal proportions (FA_50-GGBS_50). Sodium silicate (Na_2SiO_3) and sodium hydroxide (NaOH) solution has been used as alkaline activator. Polypropylene fibers are used at fiber dosage of 0.1%, 0.15%, 0.2%, and 0.25% by volume of concrete respectively. In the present investigation it is proposed to study the mechanical properties viz. compressive strength, split tensile strength and flexural strength after 7, 28 and 90 days of ambient room temperature curing. From the results, it is concluded that the mechanical properties were increased till polypropylene fibers are added up to 0.2% and decreasing trend has been observed at 0.25% of fibers. It is concluded that optimum percentage of fibers used was 0.2% respectively.

Key words: Geopolymer concrete, Polypropylene fibers, Compressive strength, Split tensile strength and Flexural strength

1. INTRODUCTION

Concrete is one of the most widely used construction materials and it is usually associated with Portland cement as the main component for making concrete [1]. Geopolymer can be considered as the key factor which does not utilize Portland cement, nor releases greenhouse gases. The geopolymer technology proposed by Davidovits [2] shows considerable promise for application in concrete industry as an alternative binder to the Portland cement. Davidovits proposed that binders could be produced by a polymeric reaction of alkaline liquids with the silicon and the aluminium in source materials of geological origin or by-product materials such as fly ash, slag and rice husk ash [3]. He termed these binders as geopolymers. Among the waste or by-product materials, fly ash and slag are the most potential source of geopolymers [4]. But geopolymer concrete shows week tensile nature and develops shrinkage cracking of concrete; it is a major problem in geopolymer concrete [5]. To overcome corrosion and shrinkage cracking of geopolymer concrete, sometimes the addition of synthetic fiber to the concrete mix is suggested. Synthetic fibers used in our study are Polypropylene fibers are engineered micro fibers with a unique

"Triangular" Cross-section, used as secondary reinforcement of Concrete [6].

2. EXPERIMENTAL STUDY

2.1. Materials

Our objective was to determine the optimum percentage of addition of fibers to GPC and study the strength properties viz. compressive strength, spliting tensile strength, and flexural strength of GPC, to analyse the properties after the addition of fibers and comparing that to conventional concrete. The hardened properties that were determined are compressive strength and splitting tensile strength after 7, 28 and 90 days of curing at room temperature respectively.

Fly ash

In this investigation, Class F (low calcium) fly ash produced from Rayalaseema Thermal Power Plant (RTPP), Muddanur, A.P is used as an additive according to ASTM C 618 [7]. As per IS-456:2000 [8], cement is replaced by 35% of fly ash by weight of cementitious material [4&9]. The specific gravity and Fineness of fly ash are 2.26 and 360 (m^2/Kg).

Ground Granulated Blast Furnace Slag

GGBS collected from Astrra chemicals, chennai was used in the manufacturing of GPC. The specific gravity and Fineness of GGBS are 2.84 and 400 (m^2/Kg).

Fine aggregate

Natural river sand is used as fine aggregate. As per IS: 2386 (Part III)-1963 [10], the bulk specific gravity in oven dry condition and water absorption of the sand are 2.62 and 1% respectively. The fineness modulus of sand is 2.59.

Coarse aggregate

Crushed granite stones of size 20mm and 10mm are used as coarse aggregate, natural river sand is used as a fine aggregate. As per IS: 2386 (Part III)-1963 [10], the bulk specific gravity in oven dry condition, water absorption and fineness modulus of the coarse aggregate and fine aggregate are presented in Table 1.

Table 1. Material properties

Properties	Coarse aggregate		Fine aggregate
	20 mm	10 mm	
Specific Gravity	2.56	2.56	2.62
Water absorption (%)	0.3	0.3	1
Fineness modulus	3.36	1.98	2.59

Ordinary tap water is used in the investigation during the period of casting as well as curing.

Polypropylene Fiber

Polypropylene fiber is a strong fiber. Recron'3s polypropylene fibers are utilized as a part of this study. Properties of polypropylene fibers are shown in Table 2.

2.2. Mix design of GPC

Based on the limited past research on GPC (Hardjito & Rangan, 2005), the following proportions were selected for the constituents of the mixtures[11].In the design of geopolymer concrete mix, coarse and fine aggregates together were taken as 77% of entire mixture by mass [12]. Fine aggregate was taken as 30% of the total aggregates. The density of geopolymer concrete is taken similar to that of OPC as 2400 kg/m^3 [11]. The Class F fly ash and GGBS were taken as 50-50% and the Molarity of sodium hydroxide solution was kept at 8M.

Table 2. Properties of polypropylene fibers

Description	Specifications
Shape	Triangular
Cut length	6mm
Effective diameter	25-40 microns
Specific gravity	0.9-0.91
Melting point	160^0C-165^0C
Tensile strength	4-6 (Gpd)
Density	0.91 gm/cc
Elongation at break	10-45%
Color	White
Luster	Bright to Light

2.3. Test specimens

Three cubical and cylindrical specimens of size 150 mm x 150 mm x 150 mm and length 300 mm, 150 mm diameter were cast and tested for each age and each mix for compressive strength and split tensile strength. The compressive and split tensile strength of a GPC was tested after 7, 28 and 90 days of curing.

2.4. Curing of Test Specimens

After casting and demoulding, the test specimens were kept in normal water for curing at ambient room temperature till the execution of the testing on the specimens.

3. METHODOLOGY

The short-term mechanical properties of the geopolymer concrete are evaluated by using Compressive strength test, Split tensile test and Flexural strength test. The Compressive strength test [13&14] and Split tensile test [15&16] and flexural strength test [13&17] of all specimens were evaluated by using respective codes. These samples were tested at 7, 28 and 90 days of curing at ambient room temperature.

4. RESULTS AND DISCUSSIONS

4.1 Compressive strength

Table 3 shows the compressive strength of GPC mixes (0%, 0.1%, 0.15%, 0.2% and 0.25%) at different curing periods.

Table 3. Compressive strength of GPC

Age (days)	Mix type				
	0%	**0.1%**	**0.15%**	**0.2%**	**0.25%**
7	30.04	32.53	33.92	34.56	31.19
28	39.54	41.58	43.21	45.52	39.15
90	45.68	47.23	49.53	51.62	46.18

Where, 0% is the % of fibers by volume

Compressive strength was tested for the mixes with the various percentage fiber levels of 0%, 0.1%, 0.15%, 0.2%, and 0.25%. The samples were tested after curing periods of 7, 28 and 90 days. It was observed that there was a significant increase in compressive strength with the increase in percentage of polypropylene fiber from 0% to 0.2% in all curing periods. After 7 days of curing, 0.2% polypropylene fiber sample exhibited a compressive strength of 34.56 MPa, whereas after 28 days of curing it was 45.52 MPa and after 90 days of curing it was 51.62 MPa. It is to be noted that the significant improvement in compressive strength is mainly due to the increase content of polypropylene fiber. From the results it is concluded that polypropylene fiber acts as reinforcement material and hence makes the concrete strength. However, when the percentage polypropylene was increased to 0.25% a drastic fall in compressive strength was evidenced irrespective of the time of curing. The compressive strength values of the mixes with 0.25% of polypropylene fiber were found to be 31.19 MPa, 39.15 MPa and 46.18 MPa respectively after 7, 28 and 90 days of curing. The fall in the compressive strength at 0.25% polypropylene fiber can be explained presumably due to the lower value of crushing and impact strength of polypropylene is mainly attributed to the decrease in compressive strength of GPC.

The experimental values obtained are depicted in Figure 1.This trend of increase in values of compressive strength with increasing polypropylene fiber (0% to 0.20%) and a further sharp fall in compressive strength was observed at 0.25% of polypropylene fiber.

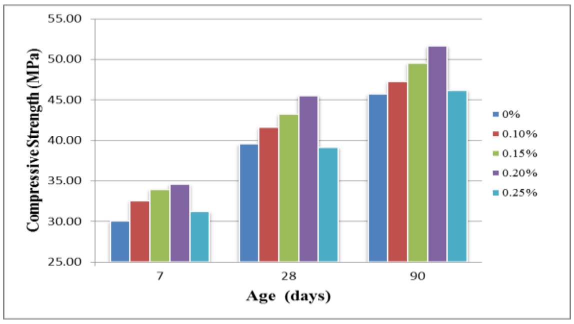

Fig 1 Compressive strength versus Age

4.2 Split tensile strength

Table 4 shows the split tensile strength of GPC mixes (0%, 0.1%, 0.15%, 0.2% and 0.25%) at different curing periods.

Table 4. Split tensile strength of GPC

Age (days)	Mix type				
	0%	**0.1%**	**0.15%**	**0.2%**	**0.25%**
7	2.59	2.89	3.01	3.42	2.53

28	3.52	3.71	3.92	4.17	3.61
90	3.81	3.94	4.09	4.37	3.83

Split tensile strength was also performed by adding polypropylene fiber with from 0% to 0.25%. The split tensile strength was found to increase with increasing percentage of polypropylene fiber up to 0.2%, independent of the age of curing. A drastic fall of split tensile strength was observed when the fiber percentage was increased further to up to 0.25%. The split tensile strength at 0.2% polypropylene fiber was found to be 3.42 MPa after a curing period of 7 days, whereas at 28 and 90 days with 0.2% MRCA the split tensile strength were 4.17 MPa and 4.37 MPa. It is to be said that polypropylene fiber acts as reinforcement material which improves the interfacial transition zone (ITZ) and leads to the improvement of split tensile strength. At 0.25% adding polypropylene fiber, the split tensile strength was very low, yielding a value of 2.53 MPa after 7 days of curing. Similarly, at 0.25% polypropylene fiber and after 28 days and 90 days of curing the STS values were observed to be very low yielding values of 3.61 MPa and 3.83 MPa. Hence, it can be recommended to use polypropylene at 0.2% by volume in order to attain the best results as compare to conventional concrete.

The experimental values obtained are depicted in Figure 2.This trend of increase in values of split tensile strength with increasing polypropylene fiber (0% to 0.20%) and a further sharp fall in split tensile strength was observed at 0.25% of polypropylene fiber.

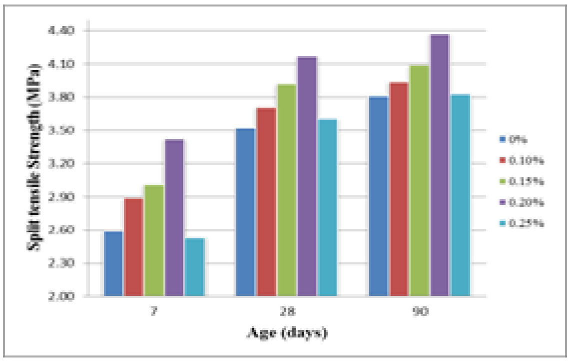

Fig 2 Split tensile strength versus Age

4.3 Flexural strength

Table 5 shows the flexural strength of GPC mixes (0%, 0.1%, 0.15%, 0.2% and 0.25%) at different curing periods.

Table 5. Flexural strength of GPC

Age (days)	**Mix type**				
	0%	**0.1%**	**0.15%**	**0.2%**	**0.25%**
7	3.41	3.59	3.77	3.95	3.45
28	3.89	4.01	4.21	4.45	3.91
90	4.28	4.43	4.61	4.82	4.34

Flexural strength was also performed by adding polypropylene fiber with from 0% to 0.25%. The flexural strength was found to increase with increasing percentage of polypropylene fiber up to 0.2%, independent of the age of curing. A drastic fall of flexural strength was observed when the polypropylene fiber percentage was increased further to up to 0.25%. The flexural strength at 0.2% polypropylene fiber was found to be 3.95 MPa after a curing period of 7 days, whereas at 28 days with 0.2% polypropylene fiber the flexural strength was 4.45 MPa. A significant improvement in flexural strength up to 4.82 MPa was observed after 90 days of curing. It is to be pointed out that polypropylene fiber acts as reinforcement material which improves the interfacial transition zone (ITZ) and leads to the improvement of flexural strength. At 0.25% adding of polypropylene fiber, the flexural strength was very low, yielding a value of 3.45 MPa after 7 days of curing. Similarly, at 0.25% polypropylene fiber adding and after 28 days and 90 days of curing the flexural strength values were observed to be very low yielding values of 3.91 MPa and 4.34 MPa.

The experimental values obtained are depicted in Figure 3.This trend of increase in values of flexural strength with increasing polypropylene fiber (0% to 0.20%) and a further sharp fall in flexural strength was observed at 0.25% of polypropylene fiber.

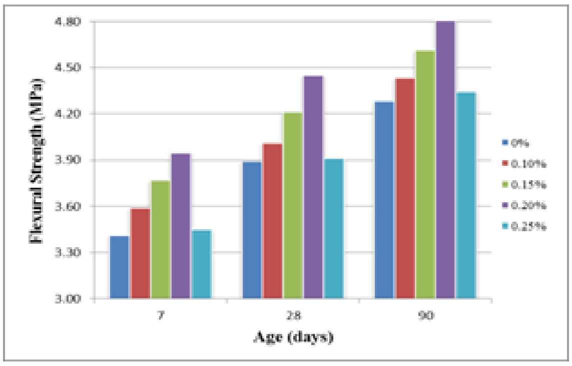

Fig 3 Flexural strength versus Age

5.CONCLUSIONS

Based on the investigation, the following conclusions have been drawn.

1. There was a significant increase in compressive strength with the increase in percentage of polypropylene fiber from 0% to 0.2% in all curing periods.
2. When the percentage polypropylene fiber was increased to 0.25% a drastic fall in compressive strength was evidenced.
3. When the percentage of polypropylene fiber increased from 0% to 0.2%, splitting tensile strength and flexural strength have been enhanced.
4. When the percentage polypropylene fiber was increased to 0.25% a drastic fall in splitting tensile strength and flexural strength have been evidenced.
5. The optimum percentage of polypropylene fiber obtained is 0.2% of its volume of concrete.
6. The significant improvement in mechanical properties up to 0.2% polypropylene fiber adding is mainly due to the blended of concrete with fibers and which fills the voids and increases the compressive strength of the concrete which in turn increases the other mechanical properties.

REFERENCES

[1]. Rangan B.V. Fly ash-based geopolymer concrete, Curtin University of Technology, 2008.

[2]. Davidovits J, Chemistry of geopolymeric systems, terminology, Proceeding of Geopolymer International Conference, Saint-Quentin, France, 1999.

[3]. Hardjito D, Rangan BV. Development and properties of low-calcium fly ash-based geopolymer concrete, Research Report GC1, Perth, Australia: Faculty of Engineering, Curtin University of Technology, 2005.

[4]. Sreenivasulu C, Ramakrishnaiah A, Guru Jawahar J. Mechanical properties of geopolymer concrete using granite slurry as sand replacement, International Journal of Advances in Engineering & Technology, 8(2015) 83-91.

[5]. Sreenivasulu C, Guru Jawahar J, VijayaSekhar Reddy M and Pavan Kumar D, Effect of fine aggregate blending on short-term mechanical properties of geopolymer concrete, Asian Journal Of Civil Engineering (Building and Housing),17(2016) 537-550.

[6]. Baghi, Hadi, and Joaquim AO Barros. "Shear Properties of the Strain Hardening Cementitious Composite Material." Journal of Materials in Civil Engineering (2016): 04016093.

[7]. ASTM C 618. Standard specification for coal fly ash and raw or calcined natural pozzolan for use in concrete, 2003.

[8]. IS: 456. Plain and reinforced concrete code for practice. Bureau of Indian Standards, New Delhi, India, 2000.

[9]. Guru Jawahar J, Sashidhar C, Ramana Reddy I.V, Annie Peter J. Effect of coarse ggregate blending on short-term mechanical properties of self compacting concrete, Materials and Design, 43(2013) 185–194.

[10]. IS 2386. Indian standard methods of test for aggregates for concrete: Part-III specific gravity, density, voids, absorption and bulking, Bureau of Indian Standards, New Delhi, 1963.

[11]. Gourley JT. Geopolymers; Opportunities for environmentally friendly construction materials, Paper Presented at the Materials 2003 Conference: Adaptive Materials for a Modern Society, Sydney, 2003.

[12]. Hardjito D, Wallah SE, Rangan BV. Study on engineering properties of fly ash-based geopolymer concrete, Journal of the Australasian Ceramic Society, 38(2002b) 44-7.

[13]. IS 516. Bureau of Indian Standards, Indian standard code of practice methods of test for strength of concrete, New Delhi, India, 1959.

[14]. ASTM C39. Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens, ASTM International, West Conshohocken, PA, 2014.

[15]. IS 5816. Bureau of Indian Standards, Indian standard splitting tensile strength of concrete -method of test, New Delhi, India, 1999.

[16]. ASTM C496. Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens, ASTM International, West Conshohocken, PA, 2004.

[17]. ASTM C78. Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading), ASTM International, West Conshohocken, PA, 2015.